MASTER OF SCIENCE
IN
SYSTEMS ENGINEERING

STREHL RATIO PROBABILITIES FOR PHASE-ONLY ADAPTIVE OPTICS

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Atmospheric turbulence will induce phase and amplitude fluctuations in propagating electromagnetic waves, such as a laser beam. Adaptive optical systems attempt to compensate for these distortions. The Strehl ratio is a measure of the peak, on-axis intensity after propagation through turbulence divided by the peak irradiance for vacuum propagation.

This thesis investigates the probability distribution of the Strehl ratio of a perfect, phase-only, adaptive optical system as a function of the atmospheric coherence length r_o divided by the actuator spacing. Using an efficient Fourier algorithm and 28 workstations running in parallel, over 850 million computer simulations were performed for 25 different d/r_o ratios in order to produce a histogram of the irradiance probability distribution. The results show that the Strehl ratio follows a log-normal probability distribution even for very small probabilities.

A second set of computer simulations introduced intensity scintillation by including the log-amplitude variance parameter, σ_Θ^2. Much faster, state-of-the-art computer workstations enabled over two billion realizations on 18 machines running in parallel for comparable time periods. The trends of these results are more complex and will require further research and deeper investigation.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Computing and Software, Modeling and Simulation

KEYWORDS: Turbulence, Atmosphere, Adaptive, Optics, Laser, Propagation, Strehl, Computer, Probability

AN ANALYSIS OF EMERGING COMMERCIAL WIDE BAND SATELLITE SYSTEMS AND THEIR POTENTIAL FOR MILITARY USE

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Spurred by the growing need of information transfer around the globe, considerable investment is being made in the private sector to develop and field new commercial SATCOM services. From the military perspective, the exploitation of this commercially developed SATCOM services becomes an attractive augmentation to expensive MILSATCOM programs especially in an era of declining defense dollars. Applications such as battlefield situational awareness, operational planning and execution, weather, telemedicine, operations and maintenance support, tailored intelligence, distance learning, training, morale, welfare and recreation services are areas where emerging commercial wide-band satellite systems such as Teledesic, Skybridge, Cyberstar, Astrolink and Spaceway might offer possible solutions.

This thesis analyzes these five commercial satellite systems in terms of their performance measures derived from the seven required characteristics as defined in the Advanced MILSATCOM Capstone Requirement Document. In addition, factors that might account for the commercial viability of these systems are also considered to determine their survivability in this competitive market place. A portion of this thesis is also devoted to illustrate current MILSATCOM architecture so as to give reader an appreciation of the present capabilities, life spans and the possible future architecture that it might take.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: MILSATCOM, Commercial Wideband SATCOM

THE EFFECT OF ELEMENT MUTUAL COUPLING
ON THE PERFORMANCE OF ADAPTIVE ARRAYS

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Adaptive arrays are highly versatile sensors employed in modern wireless communication systems to combat interference and multi-path fading and thereby increase system capacity. In adaptive processing, weights are attached to the incoming signal at each element to produce nulls in the directions of interferes. However, mutual coupling is normally ignored in such processing. Instead, the principle of pattern multiplication is used, where the assumption is that the radiation pattern of an array is the individual radiation pattern of the elements multiplied by an array factor. This assumption ignores mutual coupling and the error can be significant under certain conditions. This work begins by setting up the scenario of an adaptive array in a mobile communications scenario in a scattering environment. Following that, the theories of mutual coupling and beam-forming are introduced. Expressions for the optimum solutions and the signal-to-interference-plus-noise ratio are then derived based on the preceding discussions. Subsequently, the effects of mutual coupling are shown and the conditions under which the effect is significant. In addition, we will examine various parameters involved in our scenario will be examined and how they affect the performance of the adaptive array.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Sensors

KEYWORDS: Adaptive Arrays, Mutual Coupling, Mobile Communications